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COMPLETE SPECIFICATION.

Improvements in or relating to the contacting of gases with finely divided solids

We, STANDARD OIL DEVELOPMENT COMPANY, a corporation duly organised and existing under the laws of the State of Delaware, United States of America, having an office at Elizabeth, New Jersey, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention pertains to an improved process and apparatus for carrying out catalytic reactions wherein finely divided contact particles are held in suspension in the reactant materials and particularly to the stripping of adsorbed and/or entrained fluid materials from the solid catalyst particles utilized in the catalytic conversion of hydrocarbons.

There has been developed in recent years in certain catalytic operations, a method which is commonly referred to as the fluid catalyst method or technique in which finely divided solid catalyst particles are carried through a reaction zone in a stream of vapors undergoing reaction. This method or technique is applicable to a wide variety of catalytic reactions and while for purposes of illustration this invention will be specifically described in connection with the catalytic cracking of hydrocarbons, it is to be understood that the invention is not limited thereto but may be used in other processes, e.g., in other catalytic processes for the conversion of hydrocarbons, where it is desired to remove vapors or gases from dense, fluidized, liquid-simulating mixtures of solid contact particles and gaseous fluids.

In general, in the fluid catalyst method the vaporous reactants and catalysts are introduced into the bottom of the reaction vessel, passed upwardly therethrough and are discharged into separation equipment in which the catalyst particles are separated from the vaporous products and returned to the reaction vessel preferably after regeneration. In a modified or improved design of catalytic cracking unit, the finely divided catalysts or contact particles are continuously introduced into the reaction vessel with the hydrocarbon materials to be cracked and the velocity of the vapors is so controlled that the catalyst particles are maintained in a dense, dry, fluidized, liquid-simulating condition in the lower portion of the reaction zone. The hydrocarbon vapors or gases pass upwardly through the dense, fluidized mixture of catalyst particles at controlled velocities as indicated and the vaporous products are taken overhead from the reaction zone.

During the cracking of hydrocarbons and also in other catalytic conversions of hydrocarbon materials, coke or carbonaceous materials are deposited on the catalyst or contact particles thereby reducing or destroying their catalytic activity. The contaminated or spent catalyst particles must be regenerated before being re-used in the cracking or other catalytic operation. In the regeneration, the contaminated or spent catalyst particles are withdrawn as a dense, fluidized mixture from the lower portion of the reaction zone and the carbon or other combustible deposits are contacted with air or other regenerating gas which burns off the carbonaceous deposits.

The contaminated, spent catalyst or contact particles withdrawn from the lower portion of the reaction zone contain entrained hydrocarbon vapors or gases and before regenerating the particles it is preferred practice to remove the entrained hydrocarbons in a stripping or purging operation. The efficient stripping of hydrocarbon vapors from the spent catalyst remains an important and pressing problem even after several years of commercial operation of fluid catalyst cracking plants. Most of the commercial units are limited in their throughput by the capacity of their carbon burning systems, yet 10% to 30% of the oxygen supplied to the regenerative system goes to the combustion of gaseous or strippable hydrocarbons carried to the regenerator by the spent catalyst. Besides greatly reducing the feed

[*Price* 2/-]

throughput, these strippable hydrocarbons, amounting to anywhere from 0.5 to 1.5 wt. % on feed, represent a sizable loss of potential products. The present invention relates to an improved design for a stripping or purging section or zone for a fluidized solids reactor.

In known stripping operations the mixture of catalyst or contact particles and the hydrocarbons or other reactants are introduced into the bottom portion of a reaction zone wherein the catalyst is maintained as a dry, dense, liquid-simulating fluidized bed and catalyst is continuously withdrawn from the fluidized bed and passed through a stripping zone wherein the catalyst particles are contacted with steam or other stripping agent in order to remove the strippable hydrocarbons that are adsorbed upon or carried by the catalyst particles from the reaction bed into the stripping section. The stripping zone or section is preferably of annular form and arranged adjacent the wall of the lower portion of the reaction zone as described and claimed in Specification No. 590,868. When of annular shape the stripping zone is subdivided into a large number of cells by means of radial baffles and the single annulus or the individual cells may be provided with suitable baffles for increasing contact of catalyst particles and stripping gas which is introduced at the bottom of the stripping zone.

Since the efficacy of a stripping zone is determined by the ratio of the length to the effective diameter of the zone, subdividing the annular stripping section into a plurality of long, narrow sections or cells should give improved stripping. It was found, however, that the efficacy of such cellular strippers was not nearly as good as had been expected. It is believed that the relatively poor performance characteristic of the cellular stripper is attributable to the fact that distribution of the catalyst to the cells and flow through the cells is not uniform particularly during reactor surges and during periods of variations of flow of gases in the stripper and/or the reactor and that under some extreme conditions upflow of catalyst occurs in a number of the cells.

It has now been found that distribution and flow of catalyst through the cells can be made more uniform, upflow of catalyst in the stripping zones can be avoided and the efficiency of cellular strippers can be substantially improved if means for restricting the flow of finely divided solids are provided at the entrance to or in each of the long, narrow stripping zones, such means being adapted to produce a pressure drop of substantially 0.1 or 0.2 to 5 lbs. per square inch thereacross. In this manner positive flow of the catalyst particles downwardly in each of the stripping zones can be assured and flow of catalysts through each of the cells during reactor surges and gas flow variations in the stripper cells can be made substantially uniform.

Accordingly the invention provides improved apparatus for carrying out reactions between gaseous and vaporous materials and fluidized finely divided solids comprising a reaction vessel, means for introducing gaseous or vaporous reactants and finely divided solids into the lower portion of the vessel, means for removing reaction products from the upper portion of the vessel, a plurality of elongated stripping zones in parallel, means for withdrawing finely divided particles from the reaction vessel through said stripping zones, means for contacting the finely divided solids in the stripping zones with a stripping gas, and means for restricting and equalizing the flow of finely divided solids through the stripping zones, such flow restricting means being adapted to produce a pressure drop thereacross in the approximate range from 0.1 to 5 lbs. per square inch.

According to one form of the present invention separate catalyst entrance ports and separate stripping gas exit ports are provided in the stripping zone, the catalyst entrance ports being arranged below the level of the dense, fluidized bed-dilute phase interface and the stripping gas exit ports being arranged well up into the dilute phase. By means of this arrangement re-cycling of vapors and catalyst at the entrance to the stripper is decreased and introduction of steam or other stripping gas into the active reaction zone or dense fluidized bed is avoided. If desired, steam or other stripping agent may be injected into the catalyst entrance ports to the stripping zone. In view of the relatively high catalyst velocity in these ports, good mixing of catalyst and stripping agent can be attained by injecting the stripping agent into the catalyst entrance ports. Narrow stripping cells extend from substantially the bottom of the reaction vessel to a point well above the maximum dense bed level in the reactor. Inlet ports for the charge of catalyst from the dense bed into the long narrow stripping cells are arranged at any desired level between the perforated distribution plate and the minimum dense bed level. These inlet ports may be any desired form such as circular, semicircular, rectangular or triangular and are of such dimensions that a pressure drop through the port in the preferred range of 0.2 to 5.0 lbs. per sq. in. is produced. The catalyst level in the stripping cells is ordinarily a little lower than the dense bed level in the reactor and the cells extend a sufficient distance above the dense bed level to provide a catalyst disengaging space. The provision of a pressure drop between the dense bed and the stripping cell avoids recirculation of the catalyst from the stripping cell back into the dense bed or active reaction zone and extension of the cells upwardly into the dilute phase

results in the discharge of the stripping vapors into the dilute phase rather than into the dense bed.

The stripper zones in accordance with the present invention ensure equal distribution of the catalyst to the several cells by reason of the fact that the catalyst inlet orifices exert a leveling effect upon the flow of catalyst to the cells during reactor surges or steam failures in the stripper cells and extension of the radial baffles which divide the annular space into long, narrow cells. In one embodiment of the invention to be described later, these cells extend upwardly at least as high as the maximum catalyst bed level in the stripping zone prevents flow or mixing of catalyst from cell to cell. This latter feature is advantageous for if the baffles of the cells only extended to some point below the level of catalyst in the stripping section, a common reservoir of catalyst would be formed at the upper part of the stripping section and, if the flow of stripping agent to a particular cell should stop for any reason, flow of catalyst through that cell would become excessive and the common reservoir would be rapidly drained through that cell without any stripping occurring.

Steam or other inert stripping gas is introduced into the bottom portion of each stripping zone preferably at more than one point or in more than one direction so that the distribution of the stripping agent is substantially uniform over the entire cross-section of the stripping cell. The individual stripping cells may, if desired, be provided with baffles for improving or increasing the contact of catalyst particles and stripping agent.

Embodiments of the invention are illustrated in the accompanying drawings, in which:—

Figure 1 represents a vertical cross section of the lower portion of the reaction vessel embodying the invention.

Figure 2 is a transverse cross section taken substantially on the line 2-2 of Figure 1.

Figure 3 is an enlarged cross section of a single cell of the stripping section showing a suitable baffle and stripping agent inlet arrangement.

Figure 4 is a sectional view of the bottom portion of a stripper cell showing means for distributing the stripping steam.

Figure 5 is a sectional view of a catalyst-flow restriction orifice provided with stripping steam distributor means in close proximity thereto.

Figure 6 is a plan view of the orifice and steam distributor shown in Figure 5.

Figure 7 represents a vertical elevation partly in section of a preferred form of apparatus embodying the invention and having separate catalyst inlet ports and separate stripping gas outlet ports.

Figure 8 is a vertical cross section of a stripper cell provided with another form of baffle suitable for forming separate catalyst inlet ports and separate stripping gas outlet ports for the stripper cell, and

Figure 9 is a cross section of a different form of baffle.

Referring now to Figure 1 of the drawing, the reaction vessel (10) comprises an upper hemispherical dome section (11) a large cylindrical section (12) and a frusto-conical bottom section (13) and is provided with an inlet line (14) for introducing a mixture of reactants and catalyst or contact particles. The catalyst particles are introduced into line (14) from a standpipe or the like (15) which is equipped with a valve (16) for controlling the rate at which the catalyst particles are supplied to line (14) from the standpipe (15). The suspension of solid catalyst or contact particles in reactant vapors is passed through feed line (14) into an inlet chamber (17) comprising an upwardly flared wall member (18) and a grid member or perforated distribution plate (19) at its upper end. In the form of the apparatus shown in the drawing, the reaction vessel is circular in cross section and the grid member (19) is circular and centrally arranged in the reaction vessel. The diameter of the grid member (19) is less than the internal diameter of the reaction vessel to provide an annular passageway for the withdrawal of catalyst particles from the lower portion of the reaction vessel as will be hereinafter described in greater detail.

The velocity of the gaseous reactant fluid passing upwardly in the reaction vessel (10) is preferably so controlled as to maintain the solid contact or catalyst particles as a dense fluidized liquid-simulating dry mixture or bed (20) having a level indicated at (21). The vaporous reaction products leaving the dense bed (20) entrain a small amount of solid catalyst particles forming a dilute phase or suspension designated at (22) in the upper portion of the reaction vessel (10).

The reaction products and entrained catalyst particles are passed through separating means (23) arranged in the upper portion of the reaction vessel. This separating means, which may be a cyclone separator or the like, separates most of the entrained solid catalyst particles from the vaporous reaction products. The solid catalyst particles separated in the cyclone (23) are returned to the dense bed (20) through the dip leg or pipe (24) which extends below the upper level (21) of the dense bed (20). A valve for controlling return of catalyst particles to the dense bed and means for introducing steam or other fluidizing gas may be provided in the dip leg (24). The vaporous reaction products leaving the separating means (23) pass overhead through line (25) and may then be passed to any suitable equipment to effect further removal of entrained solids and to recover the desired

products. In the catalytic cracking or conversion of hydrocarbons the vaporous reaction products are passed to a fractionating system to separate gasoline or motor fuel from gases and higher boiling hydrocarbon constituents.

Removal of catalyst particles from the dense phase or bed (20) is effected through the stripping zone generally indicated at (26) which is formed between the inner wall of the cylindrical shell (12) and a smaller diameter concentric vertically arranged sleeve (27) which surrounds the distribution plate (19) and extends some distance above and also below the said distribution plate. The upper end of the conical wall member (18) is secured as by welding to the distribution plate (19) as well as the sleeve member (27). Secured to the bottom of sleeve member (27) is a conical baffle or wall member (28) for reducing the effective volume below the inlet chamber (17). The conical member (28) is arranged substantially equidistant from the lower conical section (13) of the reactor and is provided with a vent hole (29). A steam bleeding line (30) is provided for supplying steam or the like, to the chamber (31) formed between walls (18) (27) and (28) in order to prevent the accumulation of catalyst particles in said chamber.

The annular space (26) formed between the inner wall of the cylindrical shell (12) and the cylindrical sleeve (27) is subdivided into a plurality of long and narrow stripping zones or sections by means of radial baffles (32) which are substantially the same height as the cylindrical sleeve (27) and which extend from the outer wall of cylindrical sleeve (27) to the inner wall of cylindrical shell (12). The number of baffles (32) and accordingly the number of stripping zones provided may be varied as desired. Commercial units having an internal diameter of 25-30 feet may, for example, have the annular stripping section divided into about 40 to 70 or even more stripping zones or cells. An inlet (33) for the supply of steam or other stripping agent is arranged at the bottom of each of the stripping cells, the several inlets being in turn connected to a manifold (34) which is connected by line (35) to a source of supply of stripping gas. The stripping cells are preferably provided with suitable inclined baffles (36) in order to increase the mixing or contact of the upflow of stripping or purging gas and the downflowing spent or contaminated catalyst particles. As shown, the inclined baffles extend alternately from the outer and inner cylindrical wall member (12) and (27) in order to force the catalyst particles to follow a sinuous course down through the stripper cells. The baffles could also be in the form of alternate disc and doughnut baffles.

An orifice plate (37) is provided at the bottom of each of the stripper cells. The plates (37) are so designed as to give a pressure drop in the preferred range of from 0.2 to 5.0 lbs. per square inch across the orifice. By providing this pressure drop the flow of catalyst through the several cells is rendered more uniform and the amount of catalyst and vapor recycled from the bottom of one cell up through an adjacent cell is reduced if not completely eliminated. Flow of catalyst through cells which are not provided with a flow restricting orifice in accordance with this invention is subject to wide fluctuation during reactor surges when the dense bed catalyst level varies and particularly during failures of fluctuations in the flow of stripping steam through one or more of the cells.

The catalyst particles discharged from the stripping cells through the orifice plates (37) flow downwardly in the annular conical passageway (38) and are discharged into standpipe (39) which leads to a regenerator or the like for revivifying the spent stripped catalysts in known manner.

Figures 2 and 3 show in somewhat more detail the arrangement of stripping cell. As there shown the radial baffles (32) are secured to the inner wall of the cylindrical outer shell (12) and to the outer wall of the inner cylindrical sleeve (27) as by welding at (40). The inclined baffles (36) arranged in each of the stripper cells are secured to the radial baffles (32) or to the cylindrical sleeve (27) or the outer cylindrical wall (12). Other baffle arrangements such as alternate disc and doughnut baffles could be provided in order to increase the contact of the catalyst particles and stripping agent. The orifice plates (37) are preferably secured to the bottoms of the radial baffles (32). The orifice plates can be located at places other than the bottom of the stripper cells but placing them at higher points reduces the effective length of the stripper cell. As indicated above, the orifice plate should be designed to give a pressure drop in the preferred range of from 0.2 to 5.0 lbs. per square inch. This pressure drop suffices to even out the flow through the several cells and to prevent upflow or recycling of stripped catalysts from the bottom of one stripping cell upwardly through an adjoining cell.

The steam inlet (33) to the bottom of the stripper is shown in Fig. 1 as a single nozzle. By providing for the discharge of the stripping gas or steam at a plurality of points or in several directions it is possible to improve materially the contact of catalyst particles and stripping gas. The stripping gas inlet means can take many forms. For example, it can comprise an elongated pipe having a plurality of holes drilled therein or it can be provided with one or more side arms of the same or different size with one or more outlet holes therein or it could comprise a ring-

shaped member with a plurality of openings for the discharge of stripping gas. Uniform distribution of the stripping agent can also be achieved as shown in Fig. 4 by arranging a suitable baffle such as a disc (43), provided with a plurality of openings (44) over the outlet of a single nozzle in order to break up or disperse the stream of stripping gas.

A preferred arrangement is shown in Figures 5 and 6. In this embodiment, the stripping gas distributor is in the form of a ring (42) arranged directly above the catalyst restricting orifice plate (37). By making the distributor member in this form, even distribution of the stripping gas is achieved and by arranging the distributor directly adjacent the orifice, the catalyst particles are maintained in a fluidized condition right up to the catalyst outlet port.

Referring to Fig. 7 of the drawing, the reaction vessel (105) comprises an upper hemispherical dome section (106) a large cylindrical section (107) a frusto conical section (108) a small cylindrical section (109) and a frusto conical bottom section (110) and is provided with inlet lines (111) for introducing a mixture of reactants and catalyst or contact particles. The catalyst particles are introduced into line (111) from a standpipe or the like (112) which is equipped with a valve (113) for controlling the rate at which the catalyst particles are supplied to line (111) from the standpipe (112).

The suspension of solid catalyst or contact particles in reactant vapors is passed through feed lines (111) into an inlet chamber (114) comprising an upwardly flared wall member (115) and a grid member or perforated distribution plate (116) at its upper end. The discharge ends of the feed lines (111) are preferably flared as at (117) and a conical baffle (118) is arranged over each outlet in order to distribute the charge in the inlet chamber (114). A vent hole (119) is provided at the apex of the conical baffle plates (118) in order to prevent accumulation and stagnation of catalyst in said baffles. In the form of the apparatus shown in the drawing, the reaction vessel is circular in cross section and the grid member (116) is circular and centrally arranged in the reaction vessel. The diameter of the grid member (116) is less than the internal diameter of the smaller cylindrical section (109) of the reaction vessel to provide an annular passageway for the withdrawal of catalyst particles from the lower portion of the reaction vessel as will be hereinafter described in greater detail.

The velocity of the gaseous reactant fluid passing upwardly in the reaction vessel (105) is preferably so controlled as to maintain the solid contact or catalyst particles as a dense, fluidized, liquid-simulating, dry mixture or bed (120) having a level indicated at (121). The vaporous reaction products leaving the dense bed (120) entrain a small amount of solid catalyst particles forming a dilute phase or suspension designated at (122) in the upper portion of the reaction vessel (105) namely in the upper portions of the large cylindrical section (107) and in the dome-shaped section (106).

The reaction products and entrained catalyst particles are passed through separating means (123) arranged in the upper portion of the reaction vessel. This separating means which may be a cyclone separator or the like, separates most of the entrained solid catalyst particles from the vaporous reaction products. The solid catalyst particles separated in the cyclones (123) are returned to the dense bed (120) through the dip legs or pipes (124) which extend below the upper level (121) of the dense bed (120). Valves (125) for controlling the return of catalyst particles to the dense bed and steam lines (126) for fluidizing the separated catalyst particles may be provided in the dip legs (124). The vaporous reaction products leaving the separating means (123) pass overhead through line (127) and may then be passed to any suitable equipment to effect further removal of entrained solids and to recover the desired products. In the catalytic cracking or conversion of hydrocarbon the vaporous reaction products are passed to a fractionating system to separate gasoline or motor fuel from gases and higher boiling hydrocarbon constituents.

Removal of catalyst particles from the dense phase or bed (120) is effected through the stripping zone generally indicated at (128) which is formed between the inner wall of the small cylindrical section (109) and a smaller diameter concentric vertically arranged sleeve (129) which surrounds the distribution plate (116) and extends some distance above and also below the said distribution plate. The upper end of the wall member (115) is preferably secured as by welding to the grid plate (116) as well as the sleeve member (129). Secured to the bottom of sleeve member (129) is a conical baffle member (130) for reducing the effective volume below the inlet chamber (114). The conical member (130) is arranged substantially equidistant from the lower conical section (110) of the reactor and is provided with a vent hole (131). A steam bleed line (132) is provided for supplying steam or the like, to the chamber (133) formed between walls (115), (129) and (130) in order to prevent the accumulation of fine catalyst particles in said chamber.

The annular space (128) formed between the inner wall of cylindrical section (109) and the cylindrical sleeve (129) is subdivided into a plurality of long and narrow stripping zones or cells by means of radial baffles (134). In accordance with this embodiment of the present invention these stripping zones or

cells are extended upwardly well above the maximum dense bed catalyst level in the reaction zone. This may be readily accomplished by extending the sleeve (129) surrounding the distributor plate (116) upwardly the desired distance above the dense bed catalyst level (121) such as to (134). This extension of the sleeve (129) can be made in one or more sections and it may conform to the shape of the inner walls of the reaction vessel and be spaced a uniform distance therefrom as shown in Fig. 7, or it may, if desired, be arranged at different distances from the inner wall by making it of uniform size and shape. It could, for example, be tapered gradually to provided a relatively narrow stripping gas exit port at the top of the cells or that portion of the inner wall of the cell extending above the dense bed catalyst level could be flared outwardly to reduce the cross-sectional area of the stripping cells or flared inwardly to increase the cross-sectional area of the cells. The radial baffles which divide the annular space (128) into relatively long and narrow stripping cells or zones are also extended upwardly generally to the same height as the inner wall member (129) although any height greater than the dense bed level in the stripper cells will suffice. Ordinarily the dense bed catalyst level in the stripping cells is a little lower than the dense bed catalyst level in the reactor.

Inlet ports (135) are arranged in the walls (129) at a point above the distributor plate (116) and below the minimum dense bed catalyst level for the discharge of catalyst particles from the dense bed (120) into the stripping cells. The openings or inlet ports (135), which may be of any desired shape are of such size as to produce a pressure drop through the port in the preferred range of 0.2 to 3.0 lbs per sq. in. By providing this pressure drop through the inlet ports and extending the stripping cells above the dense bed catalyst level substantially uniform distribution of catalyst to the several cells and more uniform stripping of the catalyst can be achieved. This is due to the fact that the restricted catalyst inlet ports even out the flow of catalyst to the strippers under abnormal conditions such as surges in the reactor bed level or failure of supply of stripping agent to one or more stripper cells.

The number of baffles and accordingly the number of stripping zones or cells provided may be varied as desired. A commercial unit having an overall height of 53 feet from the bottom of the smaller cylindrical section to the center line of the cyclone inlet and having an internal diameter at the said smaller cylindrical section (109) of 30 feet, has been divided into 44 stripping zones. However, 70 or even more stripping zones may be provided if desired. Inlets (137) for the supply of steam or other stripping agent are arranged at the bottom of each of the stripping cells. The stripping cells may if desired be provided with suitable baffles (138) and (139) in order to increase the mixing or contact of the upflow of stripping or purging gas and the downflowing spent or contaminated particles as shown in the right hand stripping cell of Fig. 7. Although adequate stripping can be obtained in an unbaffled cell such as is shown in the left-hand stripping cell of Fig. 7, particularly if the stripping gas inlet (137) is provided with a number of nozzles (140) to distribute the stripping agent uniformly over the cross-section of the stripping cell, disc and doughnut baffles can be provided as shown in the right-hand stripping cell of Fig. 7.

The catalyst particles discharged from the stripping cells flow downwardly in the annular conical section (142) and are discharged into standpipe (143) which leads to a regenerator or the like for revivifying the spent, stripped catalysts in known manner.

The baffle member (129) need not conform to the shape of the reactor vessel since other forms are equally if not more suitable. Other forms of baffles which may be used are shown in Fig. 8 and Fig. 9. In Fig. 8, only a portion of the perforated distribution plate (151) and modified form of conical wall member (152) are shown. The baffle for providing separate catalyst inlet ports and stripping gas outlet ports comprises an upper cylindrical portion (153) and a lower, inwardly flared or inverted frusto-conical portion (154) the smaller portion of which has a diameter substantially the same as the diameter of the cylindrical skirt or sleeve (155), the bottom of the baffle member being arranged in close proximity to the top of the cylindrical sleeve to form the restricted inlet port (156) adapted to give a pressure drop in the preferred range of 0.2 to 5 pounds per square inch. As shown in this figure, the annular stripping zone or section (157) is subdivided into a plurality of cells by means of radial baffles of substantially the same height as the cylindrical sleeve (155) and the cell shown is further provided with baffles such as doughnut baffles (158) and disc baffles (159) in order to increase the contact of catalyst particles and stripping agent. The form of baffle shown in Fig. 8 has the advantage over the baffle of Fig. 7 of making considerably more reactor volume available for useful work. The simplest form of baffle would be the inverted frusto-conical baffle (160) shown partially in Fig. 9 having its smallest diameter substantially equal to the diameter of the cylindrical sleeve (161) and its largest diameter slightly smaller than the diameter of the shell (162), the overall length of the baffle being sufficient to extend the upper edge thereof above the maximum level

(163) of the dense bed (164) or (165) well up into the dilute phase.

The operation of the apparatus in accordance with the present invention will now be described in connection with the catalytic cracking of hydrocarbons. In such catalytic cracking operations the reactant fluid or feed stock comprise hydrocarbons such as, gas oil, reduced crude, petroleum oil, whole crude and heavy naphtha in liquid or vapor form or partly in liquid and partly in vapor form. The catalyst or contact particles may comprise acid treated bentonitic clay, synthetic silica-alumina or silica-magnesia gels or mixtures thereof with activators and promoters such oxides as zinc, calcium, thorium, boron, zirconium, vanadium, chromium, molybdenum and the like or any other suitable cracking catalyst. The catalyst particles may be of any desired form, micro-spherical particles being particularly convenient. The major proportion of the catalyst particles are ordinarily from about 20 to 200 microns in diameter.

Hot powdered catalyst such as a silica-alumina or silica-magnesia cracking catalyst supplied from standpipe (15) and relatively heavy hydrocarbon oil such as, gas oil supplied through the feed inlet in vaporized or partially vaporized condition are passed through inlet line (14) into the inlet chamber (17) at temperatures between 800° and 1,100° F. preferably at about 975° F. The catalyst to oil ratio may vary between about 5:1 and about 30:1 by weight. The mixtures of powdered catalyst and hydrocarbon vapors are passed from the inlet chamber (17) through the distribution plate or grid (19) into the reactor proper to form a fluidized dry liquid simulating mixture or dense bed (20) in the reaction vessel. Velocity of the vaporized hydrocarbon material through the bed is from about 0.6 to 2.0 ft. per second and the density of the catalyst in the dense bed (20) varies from about 10 to 30 lbs. per cu. ft.

The vaporous reaction products leaving the dense bed (20) carry along small amounts of the catalyst fines forming a dilute phase (22). The reaction products are discharged through the cyclone separators (23) for separating catalyst fines which are returned to the dense bed (20) through dip leg (24) while vaporous reaction products pass overhead through line (25) to suitable recovery or treating equipment.

During the cracking operation the catalyst particles become spent by the deposition of coke or carbonaceous material thereon. The spent or contaminated catalyst particles in fluidized condition and containing adsorbed and entrained hydrocarbon vapors and gases are withdrawn continuously through the annular stripping space (26). As the spent catalyst particles descend through the stripping cells they are contacted countercurrently with steam or other suitable stripping gas supplied through line (34). By discharging the catalyst from the stripping cell through the orifice plates (37) a substantial pressure drop is taken and uniform distribution and flow of catalyst through the several cells is achieved and the danger of upflow occurring to carry stripped catalyst particles back into the dense bed is obviated. The stripped catalyst particles pass into the conical passageway (38) and then into standpipe (39) whence they are discharged into a regenerator wherein the coke or carbonaceous deposits are burned off rendering the catalyst particles suitable for recycling to standpipes (15) and thence into the reaction vessel (10). Steam or other aerating gas may be introduced into passageway (38) through lines (41) in order to fluidize the catalyst particles.

While the improved stripper arrangement has been specifically described in connection with the catalytic cracking of hydrocarbons it is to be understood that the apparatus may be used for removing volatile material from other solid contact particles in other reactions such as the dehydrogenation of butane or butylene fractions, aromatization of naphtha fractions, coking of heavy residues and the like; and also may be used generally in other reactions involving contact of solid particles with gaseous or vaporous reactants. For example, the apparatus could also be applied in the treatment of known hydrocarbon materials such as, the oxidation of alcohol to aldehydes or acids or to the preparation of anhydrous hydrogen chloride.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for carrying out reactions between gaseous and vaporous materials and fluidized finely divided solids comprising a reaction vessel, means for introducing gaseous or vaporous reactants and finely divided solids into the lower portion of the vessel, means for removing reaction products from the upper portion of the vessel, a plurality of elongated stripping zones in parallel, means for withdrawing finely divided particles from the reaction vessel through said stripping zones, means for contacting the finely divided solids in the stripping zones with a stripping gas, and means for restricting and equalizing the flow of finely divided solids through the stripping zones, such flow restricting means being adapted to produce a pressure drop thereacross in the approximate range from 0.1 to 5 pounds per square inch.

2. Apparatus according to Claim 1, wherein said means for restricting the flow of finely divided solids through the stripping zones comprise restricted inlet or outlet ports

for the passage of said finely divided solids into and out of said stripping zones.

3. Apparatus according to claim 2, wherein said restricted inlet or outlet ports are adapted to produce a pressure drop thereacross from 0.2 to 5 pounds per square inch.

4. Apparatus according to any one of the preceding claims, wherein baffle plates are provided in each of said stripping zones to increase the contact of the solid with the stripping gas.

5. Apparatus for carrying out reactions between gaseous and vaporous materials and fluidized finely divided solids which comprises a vessel, an inlet chamber in the lower portion of said vessel for the supply of vaporous or gaseous reactants and finely divided solids thereto, an outlet for vaporous or gaseous reaction products in the upper part of said vessel, a horizontally arranged perforated member in the upper portion of said inlet chamber for distributing the reactants and finely divided solids to the vessel, a cylindrical sleeve surrounding said inlet chamber, said sleeve extending above and below said perforated member and being spaced from the inner wall of said vessel to provide an annular space for the withdrawal of finely divided solids from the vessel, radial baffles between the outer wall of said cylindrical sleeve and the inner wall of said vessel dividing said annular space into a plurality of long narrow stripping cells, means for introducing a stripping gas into the lower portion of each of said cells, a chamber at the bottom of said vessel for receiving the finely divided solids discharged from the bottom of said cells, an outlet line for the discharge of solids connected to said last named chamber and an orifice plate in each of said cells for controlling the flow of solids through said cells, such orifice plate being adapted to produce a pressure drop thereacross in the approximate range from 0.1 to 5 pounds per square inch.

6. Apparatus for carrying out reactions between gaseous and vaporous materials and fluidized finely divided solids which comprises a vessel, an inlet chamber in the bottom portion thereof for the supply of gaseous or vaporous reactants and finely divided solids, a horizontally arranged perforated member at the upper portion of said inlet chamber, said perforated member being concentric with said vessel and of smaller diameter, a vertically disposed sleeve extending above and below said perforated member and secured to the periphery thereof, said sleeve extending above the maximum level of the dense phase of finely divided solids to be maintained in said vessel and being spaced from the inner wall of said vessel to provide an annular space for the withdrawal of said solids, radial baffles of substantially the same height as said sleeve between the outer wall of said sleeve and the inner wall of said vessel dividing said annular space into a plurality of long, narrow, stripping cells, an inlet port in said vertically disposed sleeve for the discharge of finely divided solids directly from the dense phase into each of said cells above said horizontally arranged perforated plate but well below the dense upper level, said inlet port being of such size as to produce a substantial pressure drop thereacross of substantially 0.1 to 5 pounds per square inch, means for introducing a stripping agent into the lower portion of each of said cells, an outlet for reaction products in the upper portion of said vessel and an outlet for solid particles in the lower portion of said vessel.

7. Apparatus according to Claims 5 or 6, wherein baffle means are provided in said cells adapted to increase the contact between ascending stripping gas and descending finely divided solids.

8. Apparatus according to any one of Claims 5-7, wherein said orifice plate or inlet port provides a pressure drop from 0.2 to 5.0 pounds per square inch.

9. A process for carrying out gas or vapor phase chemical reactions which comprises supplying gaseous or vaporous reactants and finely divided solids to a reaction vessel, controlling the velocity of the reactants through the vessel to form a dense, fluidized, liquid-simulating mass of solids in the lower portion of said reaction vessel, removing reaction products substantially free from solid particles from the upper portion of said reaction vessel, withdrawing solid particles directly from said bed through a plurality of long narrow stripping cells, countercurrently contacting said withdrawn solids with a gaseous stripping agent in said cells, passing the withdrawn solids through an orifice plate in each of said cells providing a pressure drop of 0.2 to 5.0 pounds per square inch thereby equalizing the flow of solids through the several cells, discharging the solids from said stripping cells into a chamber at the bottom of the reaction vessel and withdrawing stripped solids from said chamber.

10. Apparatus for carrying out reactions between gaseous and vaporous materials and fluidized finely divided solids substantially as hereinbefore described and illustrated with reference to the accompanying drawings.

Dated this 29th day of November, 1948.

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Fig. 1.

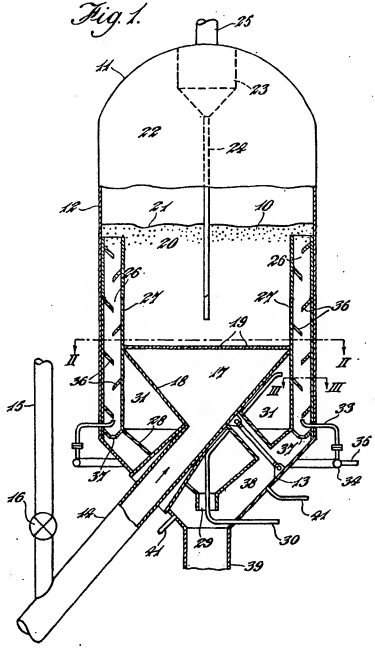
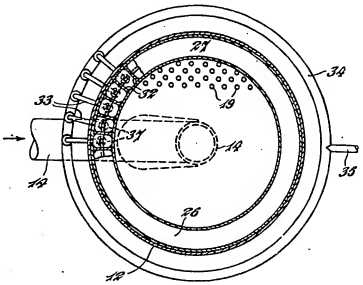


Fig. 2.



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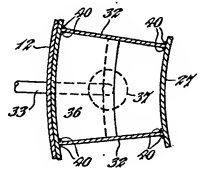

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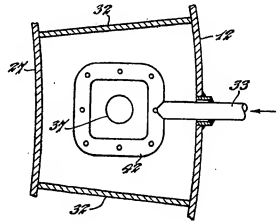

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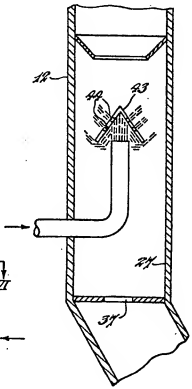

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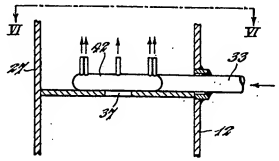
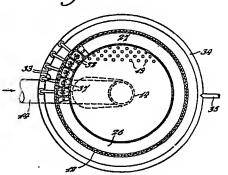


Fig. 2.



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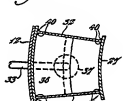

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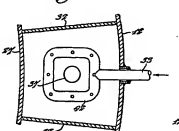

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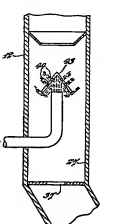

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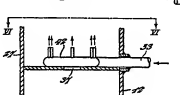
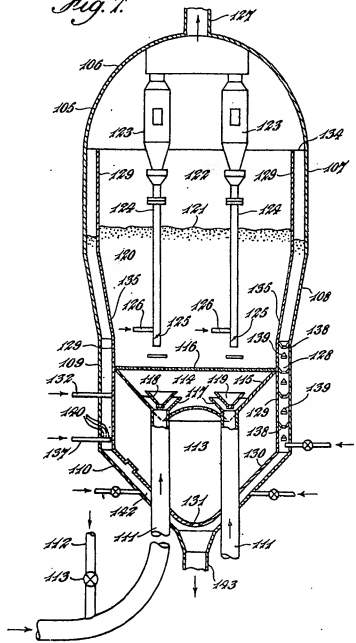


H.M.S.O. (M.F.P.)

Fig. 1.



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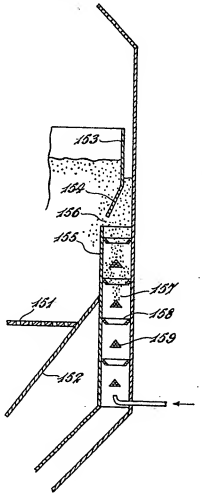

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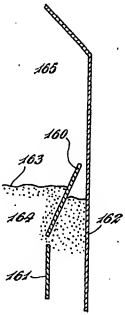

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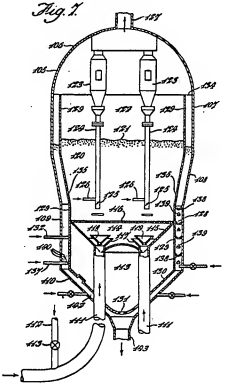

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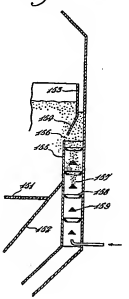

Fig. 9.